33

GEOCHRONOLOGY OF VICTORIAN MALLEE RIDGES

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Abstract

A tentative chronology for the Mallee ridges is proposed. Between the mid-Holocene parna dunes and the Upper Pliocene fluviatile deposits lie three generations of dunes. As these were dry-period structures, they may well belong to the Last Interglacial, the Penultimate Interglacial, and the Antepenultimate Interglacial respectively. The oldest dunes are eroded, cloggd with parna, and in places covered with a solid carbonate hardpan; it is easy to overlook them as former dunes.

Introduction

The marine formations underlying the Mallee have been described (Johns & Lawrence 1964, and references). Also the parna sheets and fluviatile deposits of the Murray riverine plain have been elucidated by Butler (1959 and references) and members of his organization (Churchward 1963, and references), and by University research workers such as Langford-Smith (1962). In all the above work some attention has been given to relative and chronometric dating. The writer has had the following scheme in mind for many years, and ventures it for dicussion on the occasion of the Symposium.

Mallee Ridges

The ridge morphology dominates the Mallee terrain. As a result any linear elevated area tends to be called a ridge. It should be frankly recognized that the term 'ridge' covers some four categories of structures, although some of these merge into one another, and may be superposed on one another.

1. Dune ridges, longitudinal and crescentic.
2. Depressed dune ridges.
3. Broad rises that might be called 'palimpsest ridges' because they are the faint remaining structures of what once were dunes.
4. Residual elevated areas that are outliers of ancient terrains of Tertiary age.

Relative Chronology

The above four categories are in order of relative age, and some of the evidence is as follows:

1. This category can be further divided into two, viz.:
   (a) The **white dunes** which are active now or have been in the recent past, as is shown by their sharp morphology, lack of compaction, and absence of obvious humus in the surficial sand. These are well developed, for example, in the Wyperfeld National Park. The sands are siliceous and they vary in colour from off-white to light fawn.
   (b) The **yellow dunes** are parna dunes bordering present and former lakes. Geomorphologically, they are commonly lunettes (Hills 1941), though many other shapes occur. Granulomentrically they are silts and clays, being a fine fraction formerly accumulated on lake floors, then blown up as aggregates when the lakes were dry (Stephens & Crocker 1946; Gill 1953,

1964a, b). Having a structured soil developed on them, they must be older than uncompacted white dunes without a structured soil. Isotope datings will be quoted in support of this later in the paper.

2. The depressed dunes are **red dunes**, and consist essentially of siliceous sand. These are older than the yellow dunes, as would be expected from their depressed morphology and red earth soils. Near the town of Rainbow the relative ages of the yellow and red dunes can be demonstrated. The town stands on a crescentic red dune that gives the town its name by reason of its shape. Within the arc of this dune is a parna dune which, SW. of the town, partly truncates and partly overlies the edge of this dune. Thus, erosion followed the formation of the red dune before the yellow dune was emplaced. Therefore, the yellow dune is appreciably younger than the red.

The red dunes with marked carbonate accumulations in their soils are believed to be older than those without, so making possible a subdivision also of category 2, viz.:

(a) Red dunes without carbonate nodules (as at Rainbow).
(b) Red dunes with carbonate nodules.

3. The **palimpsest ridges** are so depressed morphologically that they probably would not be thought of as ridges elsewhere. Pre-occupation with accompanying ridges, and the necessity of finding routes for irrigation channels have drawn attention to them. The soils are grossly polygenetic. A solid hardpan of carbonate is common, and may be 2 or 3 ft thick. In areas where there is no hard-rock outcrop, it is used for road metal. In the early days it was used as a building stone (e.g. churches in Hopetoun still in use). The carbonate is the B horizon of a soil whose A horizon has been lost, while the present soil is developed on material gathered disconformably on the hardpan. The hardpan follows a depressed dune terrain, so the soil of which it is a relic was formed after both the establishment and erosion of the dune. So the original dune must be very old.

Some of these older dunes are clayey. In hand specimen they appear to be granulometrically bimodal, consisting of siliceous sand of dune-building range of size, and of a fine silt-clay fraction. With each dry Interglacial, the Mallee must have become a 'dust bowl', and the fine fraction of wind-eroded sediments dusted over the terrain. In the wet period that followed, much of this parna would be washed down into the sand dunes, thus making them clayey. The remainder would be washed into lake beds and stream channels to form a supply of parna for the next dry period. A thorough grain-size study of these cycles could be scientifically rewarding.

Just as the yellow parna dune overlies the red dune at Rainbow, so the red dune overlies the palimpsest ridge on which much of the town of Rainbow is situated. At the S. end of the town in the railway reserve on the E. side of the line there is a small quarry where the solid carbonate characteristic of these depressed ridges has been quarried. Cultivated fields in the area also show quantities of carbonate rubble. Thus, there are three superposed ridges at Rainbow providing proof of relative age. There is no red dune with carbonate nodules in this sequence.

4. No dune structures older than the palimpsest dunes have been recognized. No Upper Pliocene dunes are suspected. From what is known of the climatic conditions (Gill 1953, 1961a, b), they would not be expected in the area studied.

An important tectonic event affected the sedimentary processes of the Upper Pliocene and Lower Pleistocene (and to a lesser extent the times just before and just after that span)—the **Kosciusko Uplift**. This caused the Murray Basin to be drained, so that the latest marine formations under the Mallee are apparently Lower Pliocene. The uplift rejuvenated the river; it depressed some areas but raised others, and quickened sedimentation in the depressed areas. Some of the movements were small, but because continued over long distances they became significant. Up to 500 ft of non-marine sediments were deposited in the Mallee over the marine strata, and it is from these comparatively poorly sorted fluviatile seediments that the dune sands and parna have been extracted by winnowing. The sands are the saltatory fraction, and the parna the air-borne fraction.

As the E. half of the Mallee has no marine rocks under it, and as in the W. half the marine rocks are buried at depth, I cannot follow Blackburn's suggestion (1962) that the dunes are stranded marine shoreline structures. If they were, shallow water marine sandstone should pass up into beach sands, and they into dune sands as occurs in the postglacial, Last Interglacial and Penultimate Interglacial deposits in the Warrnambool-Port Fairy district (Gill 1966), and in the Lower Pleistocene (Werrikooian) at Devil's Den on the Glenelg R. (for locality see Fig. 10, Singleton 1941).

Hills (1939) suggested that faults in the bedrock account for some of the ridges; if so, the results are amazingly even considering the distance they extend, the irregularity of the bedrock, and the varying compaction of the Cainozoic sediments involved. Unless the displacements are recent, erosion would have obliterated them in view of the softness of the surficial sediments, and the instability of the terrain.

Red sandstone occurs in the cores of some of the dunes. This can be from Lower Pliocene lateritic profiles, Upper Pliocene rubifications, or remnants of Lower to Middle Pleistocene red dunes.

A section revealed in a quarry on the Swan Hill-Ultima road about two miles E. of Ultima is helpful. It occurs on the E. edge of a red dune at the commencement of a flat area. The succession is as follows (Munsell colours are for dry samples):

Surface 0″ — 1′ 8″	Dark red 2.5YR 3/6 structureless lightly compacted poorly sorted sand merging rapidly into
1′ 8″ — 3′	red 2.5YR 4/6 firm sandy clay to clayey sand, poorly sorted.
3′ — 6′	Compact mottled red and pale grey poorly sorted clayey sand (red 2.5YR 4/6 to 7.5YR 7/2 pinkish grey).
6′ — 8′ 6″	Very compact reddish yellow 7.5YR 6/6 poorly sorted sand, with bands of carbonate up to 1½″ thick.
8′ 6″ — 10′	Same but harder and including numerous nodules ½″-1″ in diameter, comonly oval in section, poorly sorted, brownish yellow 10YR 6/6. Thickness of this horizon varies from 2′-3′ thick. Orange bands 1″-2″ thick where iron oxide present.
10′ — 11′ 6″	Lightly compacted orange sand, with dark red iron-rich bands, forming an aquifer (Colours 10IR 6/6, 7.5YR 6/6, 10R 4/4).
11′ 6″ +	Light grey 5Y 7/1 fine poorly sorted sand. This horizon is at least six feet thick; the coarseness of the sand varies considerably.

I am indebted to Mr A. M. Gill for help in describing this section. The profound leaching and kaolinization of the sands in the bottom of the quarry are characteristic of the Nunawading Terrain (Gill 1964a), which has been traced from N. Tasmania to S. Queensland. It is also characteristic of the pallid zone of a laterite (Timboon Terrain), and to which of these terrains it belongs cannot be ascertained on present information. The Nunawading Terrain penetrates to as much as 150 ft, while the pallid zone of the laterite is not usually very thick. Rowan & Downes (1963, p. 17) refer to evidence of lateritization in the Mallee.

Absolute Dating

The relative ages of the various structures have been indicated, and their absolute ages may now be considered.

1. The parna dunes on the beaches of recent lakes are mid-Holocene in age as has been shown by radio-carbon dating, e.g. at L. Weeranganuck a lacustrine beach deposit with bones passes up into parna dunes. The bones gave a ^{14}C age of 6435 ± 110 years B.P. (Gill 1964b). The parna dune is therefore a little younger than this date.

2. The laterite (Timboon Terrain) in Victoria is of Lower Pliocene age, as is shown by marine fossils (Gill 1964a). At Grange Burn near Hamilton in W. Victoria, the waning effects of lateritization are impressed on the surface of a basalt (Gibbons & Gill 1964) which overlies an Upper Pliocene terrain developed over Lower Pliocene (Kalimnan) marine beds. The age of the basalt by potassium/argon dating is 4·35 mill. years (Turnbull, Lundelius, & McDougall 1965).

3. Non-marine sedimentation on the E. side of the Mallee area was synchronous with marine Lower Pliocene sedimentation on the W. side. Superimposed on both are Upper Pliocene non-marine beds.

4. The parna dunes represent a minor cycle, but each of the other types of dune ridge appears to represent a major cycle. They belong to drier periods, which in this area means Interglacials. If three Interglacials are involved, they must be the Last, the Penultimate, and the Antepenultimate. A tentative dating of the Mallee ridges is given in Table 1.

TABLE 1

HOLOCENE	Upper—White dunes (sand) Middle—Yellow dunes (parna)
PLEISTOCENE	Last Interglacial—Red dunes (? Penultimate Interglacial—Red dunes with carbonate nodules) Antepenultimate Interglacial—Palimpsest dunes with thick carbonate hardpans
PLIOCENE Upper	Deposition of Kosciusko sediments (continued into the Pleistocene)
Lower	Deposition of marine (Kalimnan) beds in part of the area, and lateritization of the terrestrial part (Timboon Terrain)
MIOCENE	Nunawading Terrain formed. It is not known whether this terrain is represented in the Mallee.

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